June 10, 2008

Ahmet Ozkan, PE
Inca Engineers Inc.
400 112th Avenue NE, Suite 400
Bellevue, WA 98004

Re: Sound Transit East Link Non-Destructive Testing Demonstration / Evaluation
Mayes Testing Engineers Project Number S08040

Mr. Ozkan:

As requested, on June 2 & 3, 2008 Mayes Testing Engineers performed a limited reinforcing steel survey of precast, pre-stressed concrete elements in order to demonstrate three commonly used technologies used to non-destructively locate embedded reinforcement.

We understand that Sound Transit is considering the addition of light rail to the existing I-90 floating bridge between Seattle Mercer Island, and that the Washington State Department of Transportation (WSDOT) had questions regarding the ability of current non-destructive testing (NDT) methods to locate the mild steel and post-tensioned reinforcement within the bridge pontoon decks, and the selection of an appropriate technology for the project.

Mayes Testing Engineers recommended to Sound Transit via CH2M Hill that, given the conditions as they had been presented to us, ground-penetrating radar was the most appropriate method for use as a primary detection tool, with electromagnetic (pachometer) detection and radiography (x-ray) as supplemental test methods.

This demonstration was requested by WSDOT to show the accuracy and feasibility of the above test methods. The initial demonstration was performed June 2 on surplus precast, pre-stressed concrete elements stored at the WSDOT Geneva maintenance facility in Federal Way, Washington. A follow-up demonstration was performed June 3 on the western most pontoon of the I-90 floating bridge (Pontoon A).

Test Methods

<u>Ground-Penetrating Radar (GPR)</u>

Ground penetrating radar (GPR) is a non-destructive detection method that uses high frequency pulsed electromagnetic waves to locate reinforcing steel or other embedded items by the difference in their dielectric properties. Energy is propagated into the structural element and is reflected back from boundaries at which there are electrical property contrasts. This method allows for deeper detection of embedded items than pachometer, but cannot determine bar diameter.

Pachometer

Electromagnetic detection (pachometer) is a sensitive electronic device that non-destructively detects the presence of reinforcement, or other metallic object(s), embedded in concrete by changes in a magnetic field. Whether reinforcing can be located depends upon concrete cover, reinforcement size, reinforcement spacing, and interference from other metal objects. Pachometer is an excellent survey tool, but was not recommended as the primary detection method due to its more limited ability to detect objects (such as post-tensioned reinforcement) below the top mat of mild steel reinforcement.

Radiography (X-ray)

Radiographic testing (x-ray) is a non-destructive test method that utilizes a radiation-emitting source (typically Iridium192 or Cobalt 60) to produce an image on a film plate. The radiation source is placed on one side of the element being tested, and a film plate is placed directly on the opposite side. High density embedded metal items, such as steel reinforcement, shield the film from being exposed to the radiation source versus the less dense surrounding concrete, thus producing a black and white image of the embedded reinforcement.

X-ray testing is widely considered the most definitive of the detection methods available, but it is not well suited towards surveying large areas, primarily because it is time consuming and requires establishing a radiation safety zone around while the image is being exposed. Depending upon the source being used and the thickness of the concrete element being tested, exposure times can range from several minutes to on the order of 1 hour, plus additional time to develop the image.

Results

WSDOT Geneva Maintenance Facility

An 8-foot tall by 5-foot wide freestanding section of a surplus precast, pre-stressed concrete wall was scanned for reinforcing steel by both pachometer and GPR, the results of which were marked on the concrete surface and compared with design drawings for the wall. Both pachometer and GPR successfully identified the locations of the vertical mild steel reinforcing bars placed at generally 10½-inches on-center and the horizontal mild steel reinforcing bars placed at generally 12-inches on-center. Both pachometer and GPR were also able to locate the three horizontal grouted post-tension ducts near the exposed concrete surface, located at 16, 48 and 68½-inches above the bottom of the wall. However, GPR was the only method of these two able to detect the three vertical grouted post-tension ducts placed at mid-depth of the 14-inch thick concrete element.

Two x-ray images were performed of the subject test element; one to resolve an apparent discrepancy between pachometer and GPR regarding the location of vertical reinforcement, and a second to resolve an apparent discrepancy between the survey results and the WSDOT record drawings.

At the location of the first x-ray image, GPR had identified the position of the vertical reinforcing bar approximately 1½-inches to the left of the position identified by the pachometer. The x-ray image showed that rather than a single vertical bar at this location, there are three bars bundled together. GPR had identified the location of the left most bar which, based upon the direction of scanning, was the first of these bars it encountered. Pachometer had identified the location of the bar that, based upon the x-ray, appears to be positioned closest to the surface of these bundled bars and therefore was the location of the peak magnetic field.

At the location of the second x-ray image, pachometer had identified an area where the vertical reinforcing steel appeared to be discontinuous. The vertical bar located 48-inches from the left edge of the element could not be detected via pachometer in an area from approximately 24-inches to 36-inches above the bottom of the wall. Further scanning with GPR also provided similar indications, while the WSDOT record drawing indicates that this bar should be continuous over the full height of the wall. The x-ray image performed corroborates the pachometer and GPR results, and does not show any indication of the vertical bar in this area.

<u>Pontoon A</u>

Pontoon A consists of an 11-inch thick top deck in the mid span, with 9-inch thick top deck sections on either side. An area representing each condition was selected at locations accessible from the pontoon's interior catwalks such that x-ray could be readily performed. These representative areas were scanned for reinforcement by both pachometer and GPR, the results of which were marked on the concrete surface. Both pachometer and GPR identified the locations the top mat mild steel reinforcing bars placed. As expected, GPR was the only method of these two able to detect the grouted post-tension ducts positioned at mid-depth of the deck.

X-ray images performed at both of these locations verified the detection of top mat reinforcing steel by both pachometer and GPR and the grouted post-tension duct by GPR.

Summary

As verified by comparison with radiography (x-ray) and with WSDOT record drawings, both GPR and pachometer were successful at locating the mild steel reinforcing bars in the both the test element at the WSDOT Geneva maintenance facility and Pontoon A of the I-90 floating bridge. GPR was also successful in locating the post-tension reinforcement in both the test element at the WSDOT Geneva maintenance facility and Pontoon A of the I-90 floating bridge.

GPR appears to be an appropriate method for locating both the mild steel reinforcement and the grouted post-tension ducts in the pontoon decks given what we understand to be the representative conditions reviewed for this demonstration survey.

Pachometer appears to be a suitable method for locating the mild steel reinforcement in the pontoon decks given what we understand to be the representative conditions reviewed for this demonstration survey, and could be used to supplement GPR testing under appropriate circumstances.

As discussed previously, radiographic (x-ray) testing is the most definitive of the three test methods reviewed for this demonstration, but would generally not be time or cost effective for a project of the scope we understand the addition of light rail to the existing I-90 floating bridge to be. X-ray could be appropriately used as a supplement to GPR to resolve potential ambiguities that could likely arise during such a project. If desired, x-ray could also appropriately be used during such a project for periodic quality assurance.

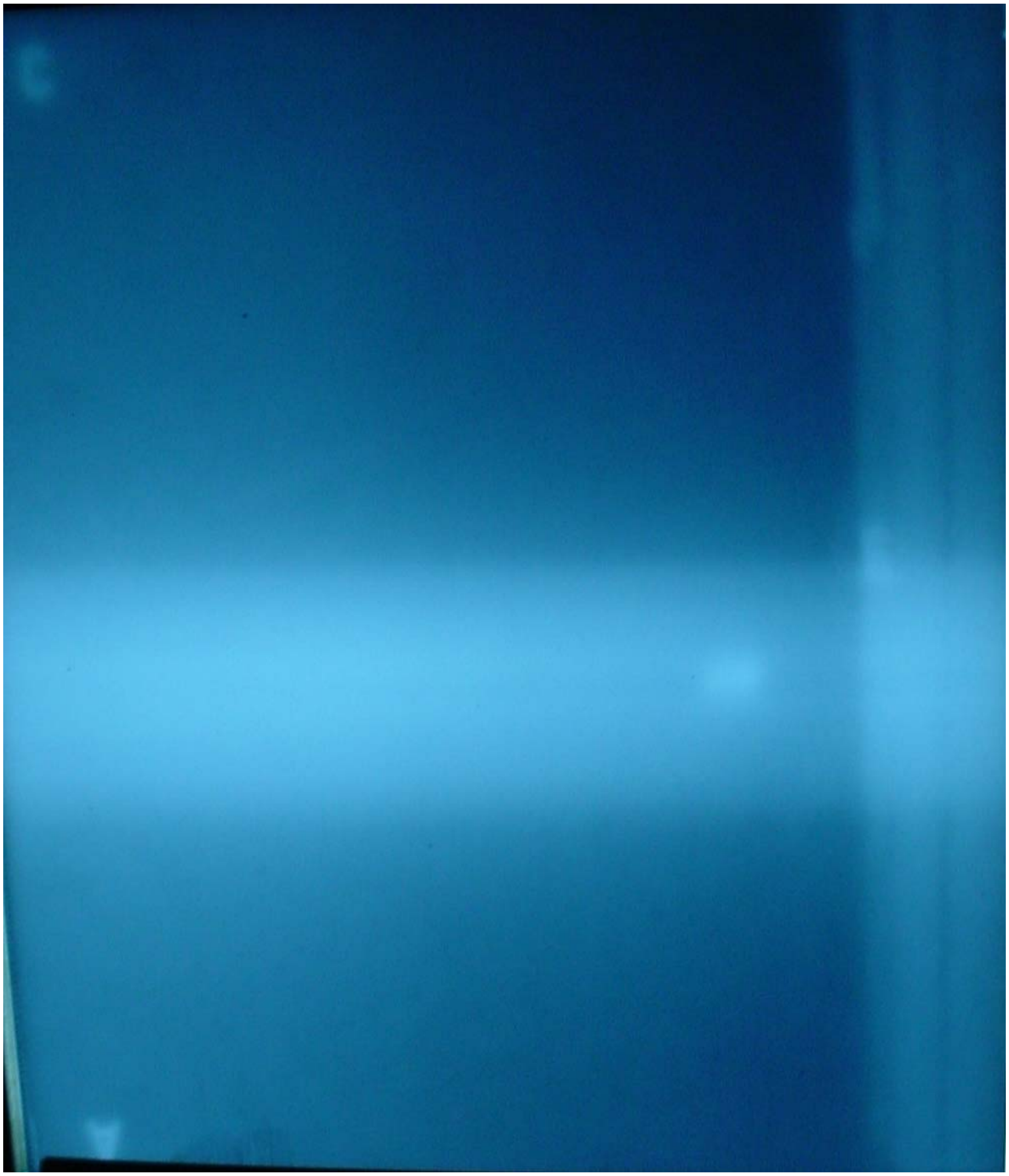
We trust that this information will provide you with the information required.

Respectfully submitted,
Mayes Testing Engineers, Inc.

Stuart J. Carter, P.E.
Special Projects Manager

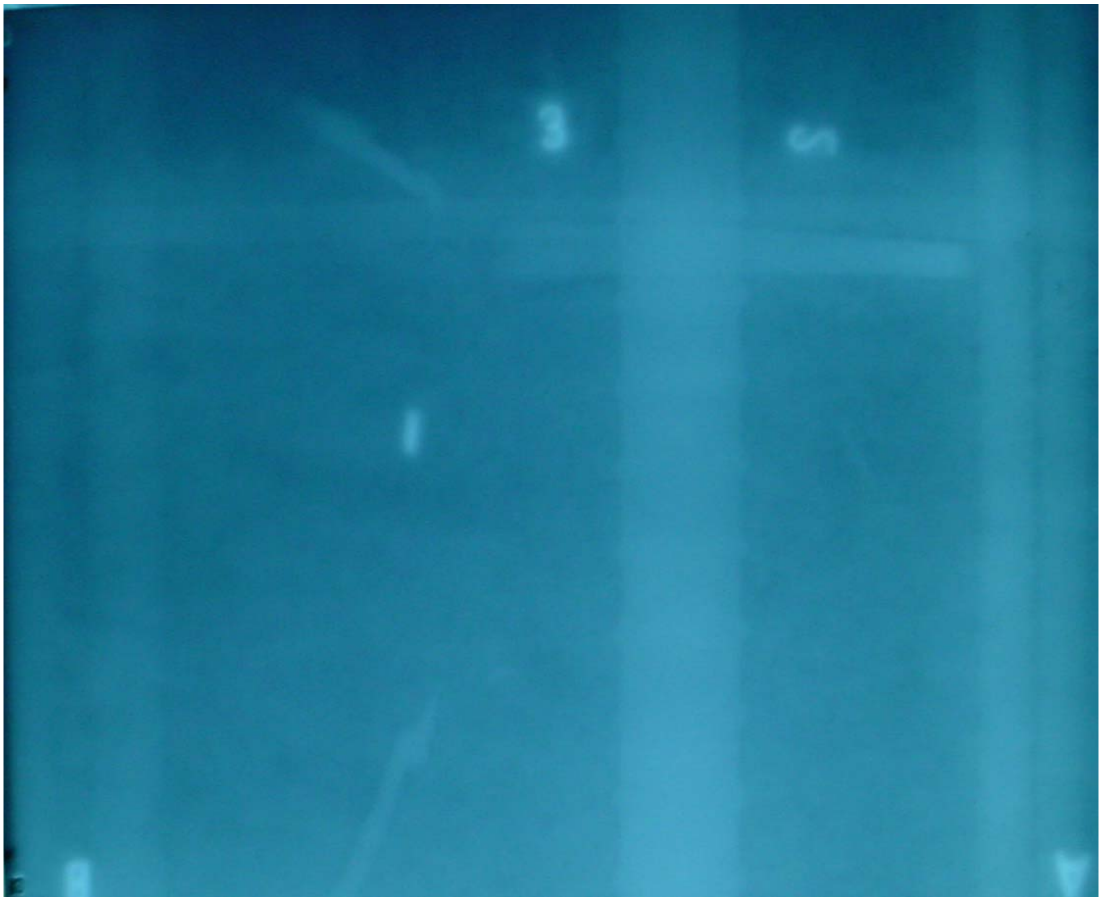
Michael S. Dolder, P.E.
Vice President

Appendix



WSDOT Geneva Maintenance Facility
Test Element X-ray #1

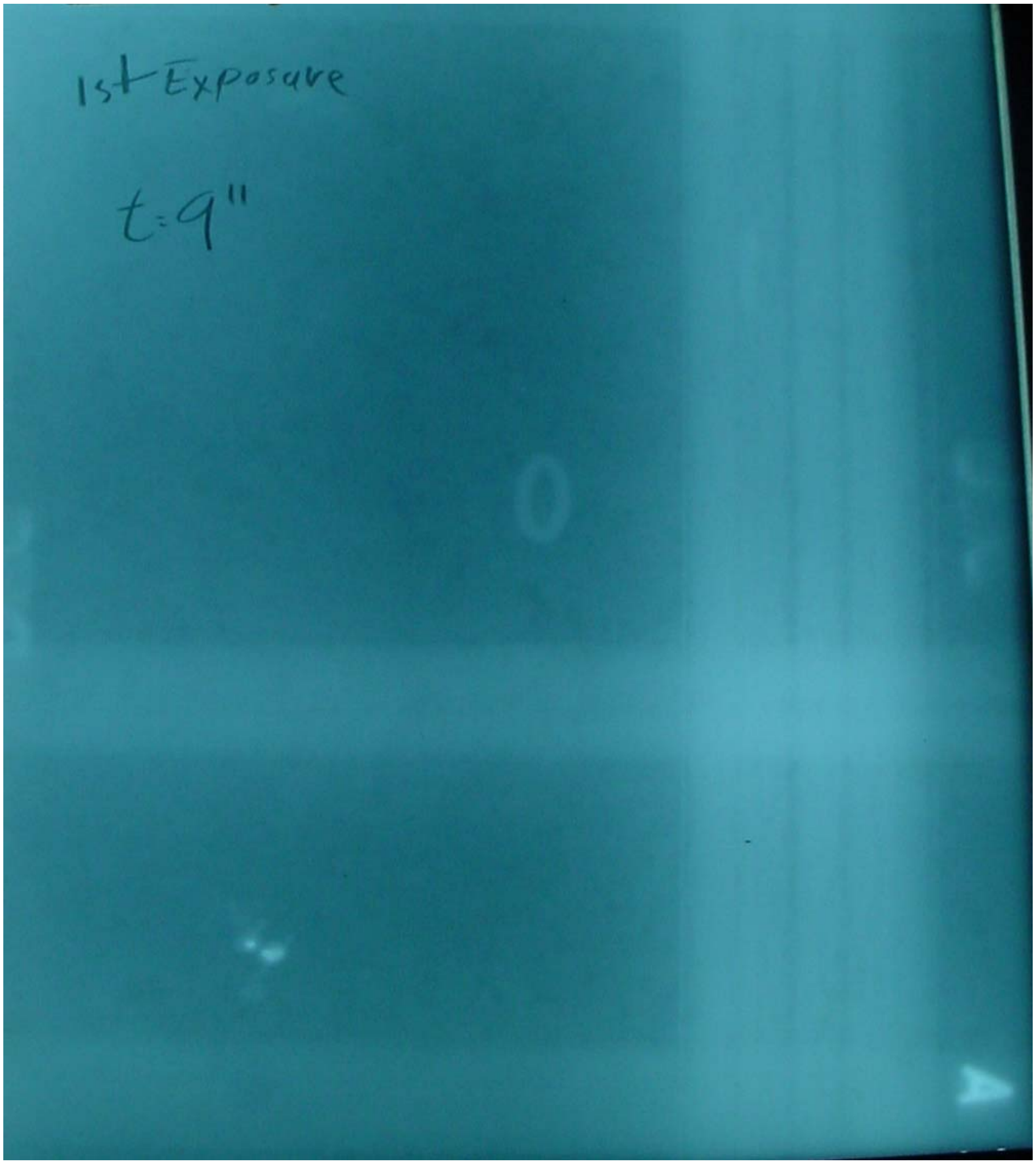
Verifies horizontal grouted duct (center)
Resolved discrepancy between GPR and pachometer regarding location of vertical reinforcing steel (right edge



WSDOT Geneva Maintenance Facility
Test Element X-ray #2

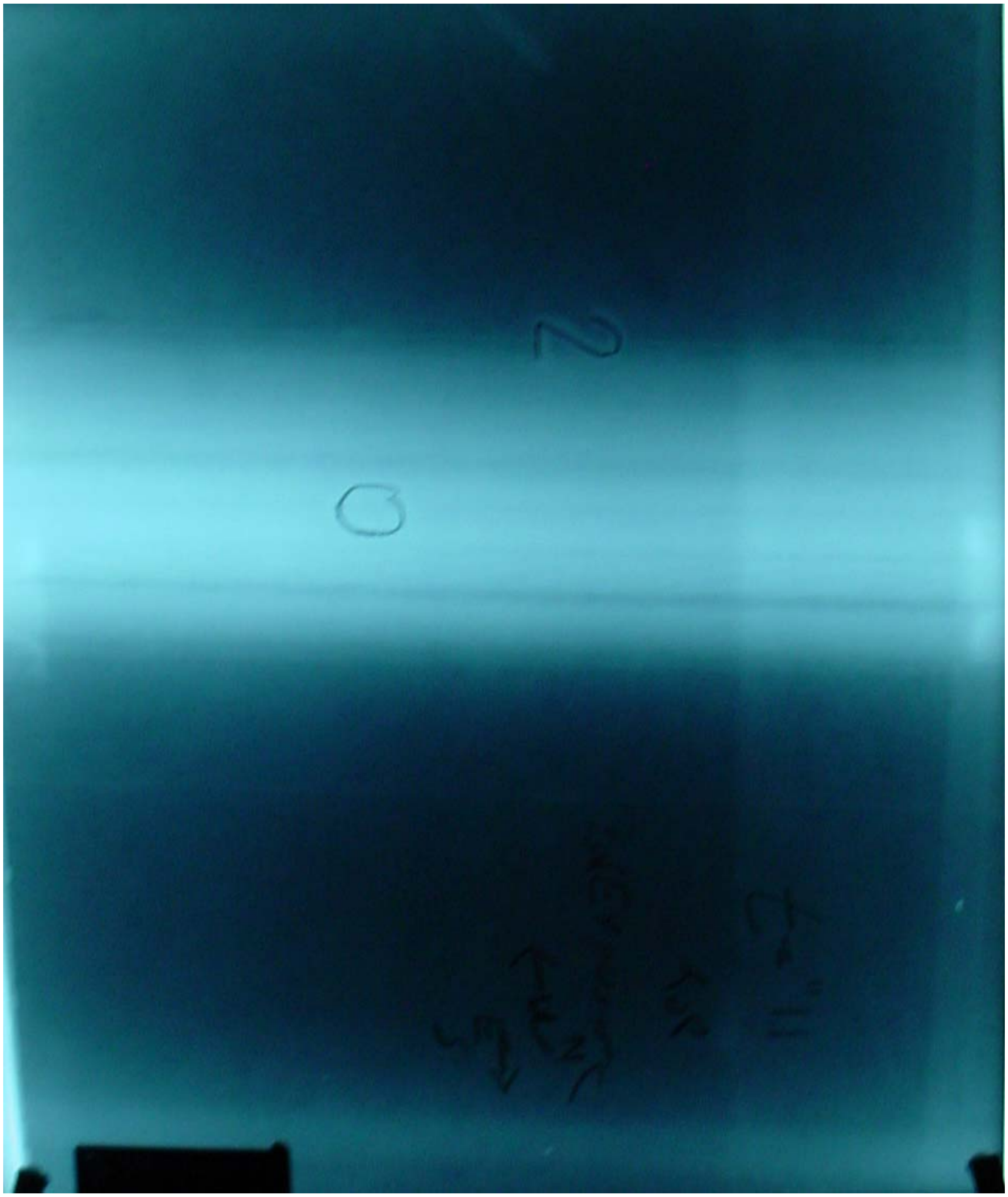
Resolved discrepancy between the WSDOT record drawings and the GPR & pachometer regarding location of vertical reinforcing steel.

Lack of vertical reinforcement at location 1 on x-ray indicates vertical reinforcement is not continuous at this location



WSDOT I-90 Floating Bridge
Pontoon A, 9-inch Top Deck Section

Verifies GPR detection of transverse grouted post-tension duct
(right side vertical in picture)



WSDOT I-90 Floating Bridge
Pontoon A, 11-inch Top Deck Section

Verifies GPR detection of transverse grouted post-tension duct (top horizontal in picture) and pachometer detection of mild steel reinforcement (left, right and bottom edges in picture)